reaches about latitude 54° and there divides into a northerly and southerly stream. At this point the maximum temperature of the water is 68° F., but the average about 60° F. As it moves down the coast it loses its heat and produces the rains and fogs of the Oregonian region, cooling off so that when it reaches the latitude of the Golden Gate it has only the temperature of 54°, or thereabouts, and is colder than the normal sea water for that latitude. It continues southward as a cold current as described by Dr. Bishop. That this essentially superficial stream is not due directly to the impinging of cold Antarctic water on the northwest coast seems to be certain from the fact that the temperature of the latter is only 32° F., while the current, when it first reaches the coast, is thirty degrees or more warmer than that; and also that the water of the current is *warmer* in latitude 54° than it is in the more southern part of its course, whereas, if it was abyssal water we should expect it to be colder and to gradually warm up as it moved southward exposed to the action of the sun.

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WASHINGTON, D. C.,
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SPECIAL ARTICLES.

ON THE PUPATION OF ANTS AND THE FEASIBILITY OF ESTABLISHING THE GUATEMALAN KELEP OR COTTON-WEEVIL ANT IN THE UNITED STATES.

IN a recent number of SCIENCE Dr. O. F. Cook publishes some of Mr. G. P. Goll's observations on the cocoon-formation of the kelep ant (*Ectatomma tuberculatum* Oliv.), apparently in the belief that similar observations have not been made on ants with enclosed pupæ. As a matter of fact, it has been known for some time that such ants bury their mature larvæ in the soil till they spin their cocoons and then, after some hours or days, unearth them and cleanse the outer surface of their envelopes. This habit has been repeatedly described for European species of *Formica*, especially by Wasmann.* It is, of course, a necessary habit, as pointed out by Dr. Cook, since the larva must have some support for the threads spun from its sericteries. In default of earth, as when ants (species of Camponotinæ or Ponerinæ) are kept in glass nests of the Fielde pattern, the workers tear off bits of sponge or toweling to spread over the larvæ as a support for the cocoon. If such materials can not be obtained, or if the larvæ are much disturbed while spinning, they will form free pupæ. I have seen this repeatedly in the case of mixed colonies of our American amazons (*Polyergus breviceps, P. bicolor* and *P. lucidus*) and their slaves, and in *Odontomachus clarus* and *Pachycondyla harpax* (a species allied to the kelep ant). The habit has been emphasized by Wasmann because it is of importance in his discovery of the interesting relations of *Formica* to the parasitic beetles *Lomechusa* and *Atemeles:*

> Both *Lomechusa* and *Atemeles* larvæ are assisted in their pupation by their hosts, exactly as are the ant larvæ. The adopted larva is placed on some soft sand, and while it moves the anterior portion of the body slowly to and fro, it is surrounded with a ring of earth, which is soon built over it like an arched roof. Within this the adopted larva spins a very fine web which merely keeps the surrounding sand particles together.
>
> This is the critical moment in the development of the *Atemeles* and *Lomechusa*. The ants are in the habit after a few days of unearthing their own larvæ which spin a dense, tough cocoon, in order to cleanse and stack up the cocoons. They attempt the same with the adopted larvæ, unfortunately, since they are thereby prevented from pupating and perish, if they are not again buried and left to themselves. Only such adopted larvæ develop, as are forgotten by the ants after they have been embedded. For this reason I obtained only one imago from thirty *Lomechusa* larvæ and not a single one from more than fifty *Atemeles* larvæ.

In this connection it is perhaps timely to call attention to the fact that C. Janet* some years ago emphasized the bearing of the presence and absence of the cocoon in ants on the

* See, *e. g.*, his 'Vergleichende Studien über Ameisen- und Termitengäste,' Haag, 1890, p. 95 *et al.*, up to his recent article: 'Zur Kontroverse über die psychischen Fähigkeiten der Ameisen,' *Natur und Schule*, Bd. 3, 1904.

* 'Les Fourmis,' *Soc. Zool. de France*, Conf. 28, Fév. 1896, Paris, 1896, pp. 3, 4.

theory of development by discontinuous variations, or mutations as they are now called:

We are without doubt confronted in the ants with the disappearance of this protective envelope [the cocoon] which has become unnecessary through the incessant care lavished on the progeny by the workers.

From the point of view of the evolution of instinct it is interesting to observe that this disappearance does not take place gradually by evanescence of the cocoon, but suddenly, so to speak, since larvæ which are similar to one another and produce similar adults, either make an absolutely complete cocoon, without any signs of reduction, or make none at all.

This fact may be cited to show how sudden may be the changes that supervene in the habits of an animal. It supports the conclusions announced in a communication by my brother, M. Armand Janet, to the congress at Leyden. These conclusions, deduced from considerations of rational mechanics applied to the problem of species regarded as a position of equilibrium, tend to demonstrate that the differences between a certain form and its descendants are produced rather by quite sudden leaps than by insensible and continuous variations.

Much has been published of late, both by the government and the newspapers, concerning the advisability and feasibility of establishing the kelep ant in Texas and the other cotton-growing states for the purpose of destroying the boll-weevil. I feel at liberty to comment on this subject because for some years past I have had rather exceptional opportunities in Texas, Florida, Mexico and the Bahamas of studying the habits of a number of species belonging to the same natural subfamily as the kelep. This study has convinced me that the attempt to establish the ant in Texas will prove to be about as successful and profitable as an attempt to acclimatize in the same state some rare Central American orchid, the South African secretary bird or the Australian wombat. But in undertaking to give my reasons for this opinion, I am far from wishing that the experiment were not being tried. An experiment may, of course, be a complete failure from a purely economic standpoint and still be of considerable, albeit negative, scientific value.

At the outset I may say that I have not myself studied the living *Ectatomma tuberculatum,* though I am familiar with the insect in collections.* But Dr. Cook's account† shows that in all essential particulars its habits are the same as those of other Ponerinæ.‡

The peculiarities which the kelep shares with other Ponerinæ and which would seem to place serious obstacles in the way of establishing it in a foreign country, are the following:

1. The Ponerinæ are archaic ants which form small colonies§ and comprise no dominant species except in Australia, where the genus *Myrmecia* (the famous 'bull-dog ants') offers an interesting and instructive parallel to the marsupialia among mammals. In fact, the opossums of America bear about the same relation to our dominant mammals, like the rodents, as do the Ponerinæ to the dominant ants of the subfamilies Myrmicinæ and Camponotinæ.

2. The Ponerinæ are local and rare, and show little adaptability or plasticity in comparison with the more recently evolved and dominant species.

3. It is altogether exceptional for any of the Ponerinæ to restrict their diet to a single species of prey. In fact, the only known exception is the Texan *Leptogenys elongata,* which, as I have shown, feeds very largely, if not exclusively, on terrestrial isopods.¶ The kelep is described by Dr. Cook as capturing and consuming 'adult insects of many and diverse kinds,' so that we may be sure that it

* Dr. Cook is in error in supposing that there is anything doubtful about the occurrence of *E. tuberculatum* in Mexico. I have before me a fine series of workers taken at Tuxpan by Mr. J. F. McClendon. They agree perfectly with a typical specimen of the kelep collected by Stoll, at Retalhuleu, Guatemala, and sent me by Professor Forel.

† 'Report on the Habits of the Kelep, or Guatemalan Cotton-Boll-Weevil Ant,' U. S. Dept. Agr. Bur. Bull. No. 49, Washington, 1904.

‡ See my papers, 'A Study of Some Texan Ponerinæ,' *Biol. Bull.*, Vol. II., No. 1, 1900, and 'The Habits of *Ponera* and *Stigmatomma*,' *ibid.*, Vol. II., No. 2, 1900.

§ *E. tuberculatum* colonies contain from 20 to 110 workers each, and average between 40 and 50.

¶ 'A Crustacean-eating Ant (*Leptogenys elongata* Buckley),' *Biol. Bull.*, Vol. VI., 1904.

will not confine itself to boll-weevils, even if it succeeds in surviving the winters and floods of Texas. If we except a few vegetarian species like the curiously modified fungus-growing Attii, ants, like human beings, thrive best on a varied diet. Cook says that 'The discovery of the ant [the kelep] supplies a practical reason for the existence of the nectaries [of the cotton plant] hitherto quite unsuspected, and it suggests the further possibility that the weevil and the ant have been factors in the evolution of the cotton plant, for the weevil is not known to feed on any plant except cotton.' This statement is clearly at variance with the current views of many botanists and myrmecologists, who have compared the much exaggerated and largely fictitious accounts of the dependence of plants on protecting ants with the actual conditions.* Furthermore, even if we accept the views of Schimper and some other botanists in regard to the protection afforded plants by these insects, we should still be unable to understand why the boll-weevil was not long ago exterminated by the kelep, inasmuch as the beetle is clearly injurious to the cotton plant and hence to the supposed best interest of the ant.

The above considerations indicate that there is little probability that the kelep can be successfully established in Texas or adjoining states, or, if established, that it will be an appreciable factor in the extermination of the boll-weevil. This becomes even clearer if we glance for a moment at the more general subject of the introduction of ants into foreign countries. At first blush ants would seem to be the easiest of all insects to introduce, since the fertilized queen is long-lived and capable as an individual of producing a whole colony of all the three sexual forms so characteristic of these and other social insects. Moreover, the young brood is efficiently protected from danger by the workers and not left to shift for itself as in most insects. But when we come to enumerate the species that have been able to survive in foreign lands, we find it to be very small, limited to a few genera and comprising several more or less dubious cases. In my opinion the following are all the foreign ants that can be supposed to have established themselves in this country since it was opened up to commerce: *Tetramorium cæspitum, T. guineense* and *T. simillimum; Monomorium pharaonis, M. floricola; Pheidole megacephala, Prenolepis longicornis; P. pubens; Plagiolepis longipes,* and some doubt attaches to all of these forms except *M. pharaonis,* the tiny yellow house-ant of Old World origin. It is an open question whether *T. cæspitum* has been introduced into the United States. It seems to occur only along the Atlantic coast from Connecticut to Maryland, but it is quite possible that it may be indigenous. The remaining species in the above list are all tropicopolitan and may all be indigenous to the tropical and subtropical portions of our continent, for the conditions in these regions are much more generally favorable to ant-life than they are in temperate regions. All of these species are occasionally met with in our northern green-houses.*

Considering the ease with which incipient ant colonies and single fertilized queens are carried from one country to another in wood, hot-house plants, soil, minerals, etc., this list is surprisingly meager, even if there were sufficient evidence to prove that the species enumerated are all *bona fide* importations. Incidentally it should be noticed that none of these are Ponerinæ, but all belong to the two dominant subfamilies, the Myrmicinæ and Camponotinæ.†

One of the reasons for this small number of imported Formicidæ would seem to be the extreme sensitiveness of these insects to

* See, *e. g.*, the excellent article by Ernest Rettig, 'Ameisenpflanzen—Pflanzenameisen: Ein Beitrag zur Kenntnis der von Ameisen bewohnten Pflanzen und der Beziehungen zwischen beiden,' Jena, Gustav Fischer, 1904.

* Further study of *Formica cinerea* and *F. rufibarbis* convinces me that they can not have been imported from Europe, as I once supposed possible.

† Some idea of the number of species of ants accidentally introduced with hot-house plants at a single port (Hamburg), may be obtained from two of Forel's recent papers: 'Fourmis Importées,' *Bull. Soc. Ent. Suisse.*, Vol. 10, 7, pp. 284–287, 1900, and 'Formiciden des Naturhistorischen Museums zu Hamburg, *Mitth. a. d. Naturhist. Mus.*, 18, 1901. Anhang., pp. 78–82.

physical conditions such as soil, moisture, sunlight, etc. No animals exhibit finer geographical variations or depend more completely on a very precise environment. While a certain and even considerable range of adaptability to varying conditions undoubtedly exists in many of the species, this is confined to dominant forms, like certain Myrmicinæ and Camponotinæ, and does not extend to the archaic and relict Ponerinæ, even the most variable of which, like *Odontomachus,* are peculiarly specialized and lacking in plasticity.

But even if the physical conditions of Texas and the other southern states prove to be favorable, it is certain that the kelep will have to reckon with the ant fauna already existing in this region, and in no state of the union is this so extensive and so formidable as in Texas. It is, indeed, probable that the living will be an even greater danger than the physical environment to a species which is very far from being a dominant faunal component even in its native land.

Dr. Cook makes the statement that 'the kelep is as yet the only ant known to attack and destroy healthy boll-weevils.' A few years ago Professor A. Herrera, of the City of Mexico, sent me for identification a species of ant which he found attacking the boll-weevil. I am not sure that he has published any observations on this insect,* which occurs from Colorado through Texas into Mexico, but seems not to be found east of the Pecos River. It may be seen at its best at Fort Davis, Texas, where it forms enormous colonies in grassy places about the cotton wood trees along the arroyos. Although it is extremely predatory and pugnacious, it does not sting. Of course, it is doubtful whether this ant could be induced to live in the cotton-growing portions of Texas, but it seems to me that it would be a better form for experimentation than the kelep, if, as Professor Herrera seems to have found, it really attacks the boll-weevil.

William Morton Wheeler.

American Museum of Natural History,
September 5, 1904.

* Described by me as *Formica subpolita* Mayr var. *perpilosa. Mem. y Rev. de la Soc. Cient.,* 'Antonio Alzate,' Vol. 17, 1902, p. 141.

CURRENT NOTES ON METEOROLOGY.

GENERAL CIRCULATION OF THE ATMOSPHERE.

Dr. W. N. Shaw read a paper on the 'General Circulation of the Atmosphere in Middle and Higher Latitudes' before the Royal Society, on June 2, which he summarizes in *Nature* for July 7. The isobars computed by de Bort for 4,000 meters above sea level indicate a comparatively simple steady motion around the polar axis from west to east, somewhat deflected to south or north by land or sea areas. The computed velocities of air movement on the gradients at this level are not at all unreasonable, and the directions of motion are appropriate, and are confirmed in Hildebrandsson's report on cloud motion. When the weight of the stratum of air between 4,000 meters and sea level is charted by means of sea level isobars, a circulation of the atmosphere from east to west around the cold pole in each hemisphere is indicated. The general surface pressures may, therefore, be resolved into two components, one due to the upper stratum above 4,000 meters which, alone, would produce a general circulation from west to east around the minima of pressure near the poles. The other, due to the lower stratum, if acting alone would produce a circulation from east to west. Both circulations would correspond closely with the surface distribution of isotherms. Where the one is predominant, in the lower middle latitudes, we get a resultant westerly circulation; where the other is predominant, near the poles of cold, we get an easterly circulation. And between the two there is a region of minimum pressure and a merging of the two circulations, which gives rise to the cyclonic storms of the north and south temperate zones. In the lower air the caps of relatively cold air in the polar regions stop the westerly currents which still flow in the lower latitudes, and replace them by currents from the east. Between these two currents mixing takes place, and eddies may be formed.

JAPANESE METEOROLOGICAL OBSERVATORY.

Bulletin No. 1 (1904) of the Central Meteorological Observatory of Japan, contains the following papers: 'Observations of the Earth